Ontario
Ministry of
Transportation and
Communications

MI-57

HOW TO ACHIEVE A GOOD SURFACE TREATMENT

MATERIALS INFORMATION
ENGINEERING MATERIALS OFFICE

MINISTRY OF TRANSPORTATION AND COMMUNICATIONS

HOW TO ACHIEVE A GOOD SURFACE TREATMENT

By
J. Cooper and R. Aquin

Additional copies may be obtained by writing to:

Ministry of Transportation and Communications
Engineering Materials Office
Bituminous Section
Central Building, Room 317
1201 Wilson Avenue
Downsview, Ontario
M3M 1J8

(416) 248-3688

Materials Information Report No. 57 January, 1984

HOW TO ACHIEVE A GOOD SURFACE TREATMENT

TABLE OF CONTENTS

		PAGE
1.0	INTRODUCTION	1
1.1	Definition	1
2.0	MATERIALS	1
2.1	Asphalt Emulsion	1
2.2	Class 1 Aggregate	2
2.3	Class 2 Aggregate	2
2.4	Class 3 Aggregate	2
2.5	Class 4 Aggregate	2
3.0	SELECTING A SURFACE TREATMENT	2
3.1	Factors Affecting the Surface Treatment Type	3
3.2	Recommended Surface Treatment Types	4
4.0	EXAMINATION OF EXISTING PAVEMENT	4
4.1	Potholes	4
4.2	Cracks	4
4.3	Alligator Cracks	5
4.4	Depressions	5
4.5	Broken Edges	5
5.0	PREPARATION FOR CONSTRUCTION	5
5.1	Weather	5
5.2	Sweeping the Pavement	6
5.3	Approval of Aggregates	6
5.4	Selection and Approval of Emulsion	6
6.0	CHECKING THE EQUIPMENT	6
6.1	The Distributor	6
6.2	The Aggregate Spreader	7
6.3	Rollers	8
6.4	The Power Broom	8
7.0	CHECKING APPLICATION RATES	8
7.1	The Trial Area	9
7.2	Average Daily Application Rates	10
8.0	THE SURFACE TREATMENT OPERATION	11
8.1	Spraying the Emulsified Asphalt	11
8.2	Spreading the Aggregate	11
8.3	Rolling	11
8.4	Longitudinal Joints	12
8.5	Transverse Joints	12
8.6	Spraying Intersections	13
8.7	Traffic Control	13
8.8	On Site Sampling of Emulsion and Aggregate	14
9.0	APPENDIX	14
9.1	MTC Forms 303 and 304, March, 1982	14
9.2	Table 1, Kilograms (Gal) of Emulsion Per Km	15
9.3	Table 2, Recommended Surface Treatment Types and Application Rates	16
9.4	Zahn Viscosimeter Test For Emulsified Asphalt	17

HOW TO ACHIEVE A GOOD SURFACE TREATMENT

1.0 INTRODUCTION

Good surface treatments are easily constructed. The basic requirements are a sound base, and choosing the correct type of aggregate and emulsion. Next, through the use of good equipment, proper application rates and established construction practices in favorable weather, success is almost guaranteed. The guide explains the necessary steps to achieve a good surface treatment.

1.1 Definition

A surface treatment is a wearing surface constructed by spraying an emulsified asphalt binder, followed by an application of aggregate which is rolled. Surface treatments may be applied to existing bituminous pavements, including primed surfaces.

2.0 MATERIALS

The materials used for surface treatments are asphalt emulsions and aggregates. There are six grades of emulsions and four types of aggregates normally used for surface treating in the Province of Ontario.

2.1 Asphalt Emulsion

Emulsions are made by combining hot asphalt cement, hot water and an emulsifying agent in a colloid mill. The colloid mill shears the asphalt into microscopic size droplets, 10 times smaller than the diameter of a human hair. When the emulsion is sprayed, the water evaporates leaving the asphalt cement to bind the aggregate to the existing surface.

The main types of asphalt emulsions for surface treatment are cationic, anionic and high float. Cationic emulsions, CRS-1 and CRS-2, work best with sandstones and granites. RS-2 is an anionic emulsion that is most suited for limestones and dolimites. High float emulsions, HF-100S, HF-150S and HF-250S, are used with graded aggregates (aggregates containing sand and stone).

2.2 Class 1 Aggregate

Class 1 aggregate is a washed chip with 100% passing the 13.2 mm sieve and 50% of the total gradation retained on the 6.7 mm sieve, and a maximum of 1% passing the 75 um sieve.

2.3 Class 2 Aggregate

Class 2 aggregate is a graded material containing stone and sand with 100% passing the 16.0 mm sieve down to a maximum of 5% passing the 75 um sieve.

2.4 Class 3 Aggregate[1]

Class 3 aggregate is HL-4 coarse aggregate with 100% passing the 16.0 mm sieve, 10% maximum passing the 4.75 mm and 2% maximum passing the 75 um sieve.

2.5 Class 4 Aggregate[2]

Class 4 aggregate is a fine aggregate with 100% passing the 9.5 mm sieve down to a maximum of 7% passing the 75 um sieve.

3.0 SELECTING A SURFACE TREATMENT

The options, under MTC specifications, include single surface treatment with class 1, 2 or 4 aggregates and double surface treatment with class 3 and 4 aggregates. From the four types you must select the most suitable surface treatment for your conditions.

A single surface treatment has a finished compacted thickness of 6 mm when class 1 aggregate is used, 13 mm when class 2 aggregate is used and 3 mm when class 4 aggregate is used. A double surface treatment has a finished compacted thickness of 13 mm when class 3 and 4 aggregates are used.

---

[1] Class 3 Aggregate is referred to as Coarse Aggregate in MTC Form 303, dated March, 1982.

[2] Class 4 Aggregate is referred to as Class 3 Aggregate in MTC Form 304 and as Sand Seal in MTC Form 303, dated March, 1982.

3.1 Factors Affecting the Surface Treatment Type

(a) Traffic Volume (AADT)[1]

Surface treatments will last longer when placed on roads with traffic volumes less than 4000 AADT. High traffic volumes cause the aggregate to polish and wear and become slippery. Compaction from high traffic volumes causes embedment of the aggregate into the underlying surface and may result in flushing and bleeding.

(b) Existing Road Surface

The softer the existing road surface, the faster the aggregate penetrates into the existing surface and flushing and bleeding result when the aggregate becomes embedded. The existing road surfaces, in order of increasing hardness, are prime, surface treatment, mulch cold mix and hot mix pavements.

(c) Availability of Aggregate

Generally, class 1 and class 3 aggregates are only available from commercial aggregate producers near large centres. It is not practical to specify a class 1 or class 3 aggregate when the aggregates would have to be hauled for great distances to the jcb site.

(d) Cost

The most economical surface treatment, in most cases, is a single surface treatment with class 2 aggregate. Class 2 aggregates are cheaper than class 1 aggregates and require less emulsion. Specifying a more costly surface treatment when not needed is not practical.

(e) Residential Areas

Surface treatment with class 2 aggregate is not recommended in residential areas because of the dust problems. Single surface treatment with class 1 aggregate or a double surface treatment with class 3 and 4 aggregates is recommended in residential areas.

---

1 AADT: Annual Average Daily Traffic

3.2 Recommended Surface Treatment Types

Table 2 aids in the selection of a surface treatment based on traffic volumes (AADT) and the existing road surface.

For example, if the existing road surface is a hot mix pavement and the AADT is 3500, then from Table 2, the options are:

Single Surface Treatment with Class 1 Aggregate (with CRS-1, CRS-2 or RS-2).

Single Surface Treatment with Class 2 Aggregate (with HF-100S)

Double Surface Treatment with Class 3 & 4 Aggregates (with CRS-2, RS-2 or HF-100S).

Your final choice will be based on cost, availability of aggregate and environmental concerns (dust).

4.0 EXAMINATION OF EXISTING PAVEMENT

Before any surface treatment work begins, an inspection of the existing pavement should be made. Existing pavements should be inspected for potholes, cracks, alligator cracks, depressions and broken edges. Plan the program allowing sufficient time to carry out the necessary repairs.

4.1 Potholes

Potholes are bowl-shaped holes usually caused by weakness in the pavement. They should be cleaned by removing loose material on the sides and bottom leaving the sides nearly vertical. Fill the potholes with hot or cold mix or repair them by spray patching. Compact the material in layers not greater than 5 cm with hand tampers or vibratory plate compactors.

4.2 Cracks

Cracks greater than 1 cm should be sealed with a suitable crack filler such as hot poured rubberized asphalt.

4.3 Alligator Cracks

Badly cracked or alligatored areas are usually caused by unstable support and are accompanied by deformation of the pavement surface. They can be repaired with hot mix, cold mix or spray patching, making sure that compaction is provided with conventional steel-tired rollers. Since unstable support is usually the result of saturated bases or subgrades, correction should include removing the wet material, installing needed drainage, ditching and compacting new granular base materials in layers not exceeding 5 cm. The new base should then be primed.

4.4 Depressions

Depressions in the pavement are caused by consolidation of the base or subgrade. They can be repaired by filling with cold or hot mix or by spray patching methods.

4.5 Broken Edges

Broken edges of a pavement are usually caused by lack of shoulder support or saturation of the base. They very often occur in thin pavements. Ditches should be cleaned, and shoulders should be graded to provide proper cross fall and then compacted.

5.0 PREPARATION FOR CONSTRUCTION

When the repairs have been completed, there are several steps to coordinate before surface treatment begins. The weather has to be right, the existing pavement swept, aggregates and emulsion must be approved and the equipment in good working order.

5.1 Weather

Surface treating must be carried out when the weather is hot and dry. Surface treating should never be started while the surface is wet or when it is threatening to rain. The combination of water, fresh surface treatment and traffic will result in the loss of most of the cover aggregate.

Do not permit surface treatment work to start or continue in cold (less than 10°C) conditions. Late fall work should be avoided at all costs. Make sure that the work is called early enough for the contractor to schedule his operation for completion by September 1st.

5.2 Sweeping the Pavement

The existing bituminous pavement to be treated must be cleaned immediately before the emulsion is sprayed. Several passes with the power broom may be necessary to remove hardened mud at entrances and intersections. The broom should overlap on the shoulder about 5 cm to ensure a clean edge of pavement.

5.3 Approval of Aggregates

The aggregates to be used in surface treatment work must be approved before work begins. Testing of aggregates for gradation and physical requirements requires approximately three weeks. Sufficient aggregate should be stockpiled in advance to complete the project.

5.4 Selection and Approval of Emulsion

A sample of the approved surface treatment aggregate should be given to the emulsion supplier to determine the most suitable emulsion. The emulsion supplier should conduct laboratory tests using the job aggregate and recommend the emulsion type.

A four litre sample representative of the emulsion to be used should be tested for quality before delivery to the job. Allow three weeks for testing.

6.0 CHECKING THE EQUIPMENT

Before work begins, the distributor, spreader, rollers and broom should be examined to make sure they are in good working order.

6.1 The Distributor

The surface treatment distributor consists of an insulated tank mounted on a truck body, an asphalt pump and a spray bar mounted at

the rear of the tank. Emulsion flows from the tank into the pump which pressurizes the spray bar.

Before spraying the distributor must be properly set up so that the emulsion can be applied within ± 5% accuracy in a continuous and uniform manner both longitudinally and across the spray bar.

The first check to make on the distributor spray bar is the condition of the nozzles. All the spray nozzles must be removed from the spray bar, cleaned and examined. Check each nozzle for nicks or damage at the slot opening. Next check that all the nozzles are the same make and same size. Nozzles of different makes or sizes are not permitted as they cause varying application rates across the spray bar.

The second check to make on the spray bar is to ensure that all the nozzles are set at the correct angle. The slot in each nozzle must be at the same angle across the spray bar. The angle is measured from the axis of the spray bar to the axis of the nozzle slot and should be 15^{o} to 30^{o}.

The third and final check to make on the distributor is the spray bar height. The spray bar must be set at the correct height above the road so that a precise double or triple lap occurs. To check that a precise double lap is set, connect every second nozzle (only a small portion of the spray bar need be used). Spray from the connected nozzles. When the correct height for a double lap is achieved, the spray fans will just appear to touch at the road surface. To check for a precise triple lap, connect and spray from every third nozzle leaving two nozzles in between disconnected. When the correct height for a triple lap is achieved the fans will appear to touch at the road surface. The spray bar must be raised or lowered so that a precise double or triple lap occurs. A triple lap is slightly better than a double lap.

6.2 The Aggregate Spreader

The spreader is a self-propelled unit capable of spreading a uniform curtain of aggregate on the road. Aggregate is dumped into the rear hopper and moved by two conveyor belts to the front hopper where it flows through metering gates onto the road. A hitch connects the spreader to the truck and the spreader pulls the truck.

The spread roller at the bottom of the front hopper should be checked to ensure that it is turning true. The spread roller is hollow and is easily bent when the hopper is removed for transit. To check for trueness, have the operator engage the spread roller with the front hopper empty, and hold a pencil close to the centre of the roller as it turns. It is helpful to steady the pencil by resting it against something solid. A spread roller with more than 3 mm of wobble can cause washboard and must be repaired before using.

6.3 Rollers

Pneumatic-tired and tandem steel-tired rollers are the most common types used for surface treatments. Rollers should be ballasted and weighed before commencing work. The steel-tired rollers must weigh at least 7 tonnes and the pneumatic-tired rollers at least 8 tonnes. Vibratory rollers are permitted providing the drum width is at least 1.25 m.

The tire pressure of the pneumatic-tired roller must be a minimum of 350 kPa cold.

6.4 The Power Broom

The rotary power broom must be in good mechanical condition and capable of thoroughly cleaning the road surface. Check the broom for excessive bristle wear and mechanical condition before work commences.

7.0 CHECKING APPLICATION RATES

The application rates of emulsion and aggregate (see Table 2 for suggested rates) should be checked before the job begins using the trial area method, and when the work is underway using the average daily application rate method.

Imperial units are used when calculating the emulsion rates in the trial area because the distributors are calibrated to spray in gallons. Metric units are used in all other calculations. Table 1 provides a handy reference to convert emulsion rates from kg/m^2 to gal./sq.yd.

7.1 The Trial Area

The trial area is one method of checking the application rates of emulsion and aggregate at the beginning of a project.

A section of road (1000 feet) should be accurately measured with a tape. The contents of the tank are measured with a dip stick[1] before spraying, and then the measured area is sprayed at the pre-determined rate. See Table 2 for general application rates. After spraying, the contents of the tank are measured again with the dip stick[1]. Spread and roll the aggregate immediately. The emulsion application rate in the trial area is calculated by dividing the gallons sprayed by the area in sq. yds.

The process is repeated until the desired application rate is obtained.

Example of trial area calculations for emulsion:

Length of trial area	1000 ft.	
Width of trial area	11 ft.	
Contents of tank before spraying		2910 gal.
Contents of tank after spraying		2510 gal.
Used		400 gal.

$$\text{Area} \quad \frac{1000 \times 11}{9} = 1{,}222.2 \text{ sq. yds.}$$

$$\text{Emulsion application rate} \quad \frac{400}{1{,}222.2} = 0.33 \text{ gal./sq.yd.}$$

The equivalent emulsion rate, 1.80 kg/m^2, is found opposite 0.33 gal./sq.yd. in Table 1.

The aggregate application rate is calculated by measuring the distance that the truck load covers with a tape and dividing the kg applied by the area covered in m^2.

---

[1] Tank should be dipped on a level section of road.

Example of trial area calculation for aggregate:

Length covered by load	312 m
Width	3.35 m
Aggregate placed	13.61 t

Area $312 \times 3.35 = 1045.2\ m^2$

Aggregate application rate $\frac{13.61 \times 1000}{1045.2} = 13.0\ kg/m^2$

7.2 Average Daily Application Rates

After each day of surface treating, the average application rates of emulsion and aggregate should be calculated. The quantity of emulsion is obtained from the Bill of Ladings accompanying each tanker load of emulsion and any emulsion not sprayed is subtacted from the total. Obtain the tonnes[1] of aggregate applied by adding the weigh tickets for that day. Measure the width of the surface treatment with a tape. Using your car odometer, measure the length of the surface treatment completed in km, to the nearest 0.01 km. Be sure to include the area of side roads in your calculations.

Example of daily application rate calculations for emulsion and aggregate:

Length completed	10.05 km
Width	6.71 m
Emulsion used	120,700 kg
Aggregate used	938.80 t

Area $10.05 \times 1000 \times 6.71 = 67{,}435.5\ m^2$

Average emulsion application rate $\frac{120{,}700}{67{,}435.5} = 1.79\ kg/m^2$

Average aggregate application rate $\frac{938.80 \times 1000}{67{,}435.5} = 13.92\ kg/m^2$

These average application rates are compared to the desired application rates and adjusted accordingly. Refer to Table 2 for the suggested application rates.

---

1. When volume measurements (m^3) are used, the density of Class 2 aggregate is 1780 kg/m^3, ie: 89 m^3 = 89 x 1780 = 158 420 kg.

8.0 THE SURFACE TREATMENT OPERATION

High quality surface treatments are the result of the emulsion and aggregate being uniformly applied at the correct rates on a previously prepared surface. The emulsion quantity must be sufficient to hold the aggregate without overfilling the voids between the aggregate.

8.1 Spraying the Emulsified Asphalt

The emulsion is sprayed with the distributor at the predetermined rate, see Table 2. The emulsion temperature should be from 60-80°C when sprayed. The distributor should not exceed 100 m/min while spraying and must stop spraying each time the spreader runs out of aggregate.

During spraying watch the spray bar for blocked nozzles. Nozzles that continually plug up indicate that the strainers in the fill line and pump discharge line require removal and cleaning.

Spraying should proceed towards the aggregate source to prevent the trucks from hauling over the fresh surface treatment and be completed by 7:00 p.m.

8.2 Spreading the Aggregate

The aggregate must be spread immediately after the emulsion is applied, maintaining a distance of not more than 30 m between the distributor and spreader.

When the desired application rate is achieved, a small device, the stop block, on the gate opening lever, should be used to maintain this setting.

The aggregate trucks should never be permitted to turn around on the fresh surface treatment.

8.3 Rolling

Aggregate falls randomly onto the road surface from the spreader. Compaction of surface treatment aggregate accomplishes the following:

1. Seats the aggregate into the binder.
2. Turns the aggregate onto its flatest side.
3. Keys the aggregate into the underlying surface.
4. Smooths the aggregate surface.
5. Forces the emulsion up through the aggregate.

Immediately after spreading the aggregate, rolling should commence with the pneumatic-tired rollers. The steel-tired roller follows the pneumatic-tired rollers so that the entire rolling operation is completed within 300 m of the spreader. The entire treated area shall receive at least two coverages from each roller. When the aggregate particles are being crushed with steel-tired or vibratory rollers they must be removed and replaced with pneumatic-tired rollers. This often occurs on roads that are distorted or have wheel track rutting.

The maximum speed of the rollers should not exceed 10 km/h. When the combination of rollers cannot keep within 300 m of the spreader, additional rollers must be added or the spreader and the distributor should stop and wait for the rollers to catch up.

8.4 Longitudinal Joints

The longitudinal or centreline joint if properly made will not be visible in the completed surface treatment. To make a longitudinal joint, spray the lane with emulsion and spread the aggregate 10 cm narrower, leaving a 10 cm strip of emulsion without aggregate along centreline. Spray the adjacent lane with emulsion, re-spraying the 10 cm strip along centreline. Apply aggregate to the full width of emulsion. Most surface treatment crews spray one or two distributor loads of emulsion in one lane, and then bring up the adjacent lane. The emulsion and aggregate are applied simultaneously maintaining the maximum of 30 m between distributor and spreader.

8.5 Transverse Joints

Each time an aggregate truck is emptied the distributor and spreader must stop, resulting in a joint across the lane called a transverse joint.

The correct method of making the transverse joint is to leave 0.5 m of emulsion free of aggregate at each stop. The distributor backs up until the rear wheels just touch the 0.5 m strip of emulsion, accelerates and resumes spraying when the spray bar passes over 0.5 m strip. Aggregate is then applied to the newly sprayed emulsion with little or no overlap of aggregate. Transverse joints made in this manner will not be visible in the completed work.

8.6 Spraying Intersections

Intersections can be sprayed with the distributor providing a roll of building paper or heavy butcher paper is used to prevent overlapping onto the main road. An intersection consists of two roads intersecting, the major road and the minor road. The surface treatment operation normally proceeds along the major road towards an intersection. Stop the operation on the major road about 20 m from the intersection. Spread the paper along the major road so that overlap on the major road does not occur.

Spray the minor road, starting in the lane having the stop sign. This is to minimize overlapping where the cars are braking and accelerating. After each application of emulsion, spread and roll the aggregate. When the minor road is completed, remove and dispose of the paper. Resume spraying on the major road as though the intersection was not there.

8.7 Traffic Control

Rapid setting emulsions require approximately two hours under ideal conditions to cure sufficiently to retain aggregate. High float emulsions take longer. Traffic, including aggregate trucks should be kept off the freshly placed surface treatment during the curing period or the traffic should be convoyed at a maximum speed of 25 km/h. The convoy shall be maintained for two hours where the AADT[1] is less than 1000, for three hours where the AADT is from 1000-2000 and for four hours where the AADT is greater than 2000.

---

1 AADT: Annual Average Daily Traffic

8.8 On-Site Sampling of Emulsion and Aggregate

Samples of emulsion and aggregate should be taken and sent to certified laboratories for testing to ensure that materials delivered to the job are on specification.

It is suggested that one 4-litre sample of emulsion be taken from each tanker load of emulsion. Samples should be taken from a spigot on the transfer line or from the end of the transfer line, after the first distributor load has been pumped from the tanker. Containers for emulsion samples can be plastic lined metal pails or wide-mouth plastic jars. Emulsion samples should be sent to the laboratory and tested immediately.

A test (Zahn Viscosimeter) that is quick and easy to perform can be conducted on the job to determine the emulsion viscosity. The test is performed before the tanker is unloaded and the emulsion can be rejected before it is used if the viscosity is not within the required limits. The complete procedure for the Zahn Viscosimeter test can be found in Appendix 9.4, along with necessary equipment and tables.

It is suggested that one 30 kg sample of aggregate per day be taken and tested for gradation. Proper sampling techniques should be used to ensure that the sample is representative of the aggregate used.

9.0 APPENDIX

9.1 MTC Forms 303 and 304, dated March, 1982.

This guide was prepared using MTC Forms 303 and 304. For more detailed information, refer to Forms 303 and 304.

TABLE 1

KILOGRAMS (GAL) OF EMULSION REQUIRED PER KILOMETRE

kg/m²	GAL/SQ. YD.	WIDTH, FEET (m)							
		9(2.743)		10(3.048)		11 (3.353)		12 (3.658)	
		kg	GAL.	kg	GAL.	kg	GAL.	kg	GAL.
0.80	.147	2194	483	2438	536	2682	590	2926	644
0.85	.156	2332	513	2591	570	2850	627	3109	684
0.90	.166	2469	543	2743	603	3018	664	3292	724
0.95	.175	2606	573	2896	637	3185	701	3475	764
1.00	.184	2743	603	3048	670	3353	738	3658	805
1.05	.193	2880	634	3200	704	3521	775	3841	845
1.10	.202	3017	664	3353	738	3688	811	4024	885
1.15	.212	3154	694	3505	771	3856	848	4207	925
1.20	.221	3292	724	3658	805	4024	885	4390	966
1.25	.230	3429	754	3810	838	4191	922	4573	1006
1.30	.239	3566	784	3962	871	4359	959	4755	1046
1.35	.248	3703	815	4115	905	4527	996	4938	1086
1.40	.257	3840	845	4267	938	4694	1033	5121	1126
1.45	.267	3977	875	4420	972	4862	1070	5304	1167
1.50	.276	4115	905	4572	1006	5030	1106	5487	1206
1.55	.285	4252	935	4724	1039	5197	1143	5670	1247
1.60	.294	4389	965	4877	1073	5365	1180	5853	1288
1.65	.303	4526	996	5029	1106	5532	1217	6036	1328
1.70	.313	4663	1026	5182	1140	5700	1254	6219	1368
1.75	.322	4800	1056	5334	1173	5868	1291	6402	1408
1.80	.331	4937	1086	5486	1207	6035	1328	6584	1448
1.85	.340	5075	1116	5639	1240	6203	1364	6767	1489
1.90	.349	5212	1147	5791	1274	6371	1401	6950	1529
1.95	.359	5349	1177	5944	1308	6538	1438	7133	1569
2.00	.368	5486	1207	6096	1341	6706	1475	7316	1609
2.05	.377	5623	1237	6248	1374	6874	1512	7499	1650
2.10	.386	5760	1267	6401	1408	7041	1549	7682	1690
2.15	.395	5897	1297	6553	1441	7209	1586	7865	1730
2.20	.405	6035	1328	6706	1475	7377	1623	8048	1770
2.25	.414	6172	1358	6858	1509	7544	1659	8231	1811
2.30	.423	6309	1388	7010	1542	7712	1696	8413	1851
2.35	.432	6446	1418	7163	1576	7880	1733	8596	1891
2.40	.441	6583	1448	7315	1609	8047	1770	8779	1931
2.45	.451	6720	1478	7463	1643	8215	1807	8962	1971
2.50	.460	6858	1508	7620	1676	8383	1844	9145	2012
2.55	469	6995	1539	7772	1710	8550	1881	9328	2052
2.60	.478	7132	1569	7925	1743	8718	1918	9511	2092
2.65	.487	7269	1599	8077	1777	8885	1954	9694	2132
2.70	.497	7406	1629	8230	1810	9053	1991	9877	2173
2.75	.506	7543	1659	8382	1844	9221	2028	10060	2213
2.80	.515	7680	1689	8534	1877	9388	2065	10242	2253
2.85	.524	7818	1720	8687	1911	9556	2102	10425	2293
2.90	.533	7955	1750	8839	1944	9724	2139	10608	2333
2.95	.543	8092	1780	8992	1978	9891	2176	10791	2374
3.00	.552	8229	1810	9144	2011	10059	2213	10974	2414
3.05	.561	8366	1840	9296	2045	10227	2250	11157	2454
3.10	.570	8503	1870	9449	2079	10394	2286	11340	2495
3.15	.579	8640	1900	9601	2112	10562	2323	11523	2535
3.20	.589	8778	1931	9754	2140	10730	2360	11706	2575
3.25	.598	8915	1961	9906	2179	10897	2397	11889	2615
3.30	.607	9052	1991	10058	2212	11065	2434	12071	2655
3.35	.616	9189	2021	10211	2246	11233	2471	12254	2696
3.40	.625	9326	2051	10363	2280	11400	2508	12437	2736
3.45	.635	9463	2981	10516	2313	11568	2545	12620	2776
3.50	.644	9601	2112	10668	2347	11736	2582	12803	2816
3.55	.653	9738	2142	10820	2380	11903	2618	12986	2857
3.60	.662	9875	2172	10973	2413	12071	2655	13169	2897
3.65	.671	10012	2202	11125	2447	12238	2692	13352	2937
3.70	.681	10149	2232	11278	2481	12406	2729	13535	2977
3.75	.690	10286	2263	11430	2514	12574	2766	13718	3018
3.80	.699	10423	2293	11582	2548	12741	2803	13900	3058

Notes:

1. The table is based on a bulk relative density of 1.00 at 15°C.
2. The units kg/m² and L/m² are interchangeable, ie. 1.80 kg/m² = 1.80 L/m²
3. The units kg and L are interchangeable, ie. 6035 kg = 6035 L
4. 1 tonne = 1000 kg.

TYPE OF SURFACE TREATMENT	APPLICATION RATES				A A D T			
	Primer or Binder		Aggregate		Existing Road Surface			
	Grade	kg/m^2	Type	kg/m^2	Gravel	Prime	Surface Treatment	Pavement
Prime	Primer	± 1.90	Class 4[1]	10.0-12.0	< 200	-	-	-
Single Surface Treatment	CRS-1 CRS-2 RS-2	1.65-1.90 or Design	Class 1	12.0-14.0 or Design	-	< 500	< 2000	< 4000
	HF-100S	1.30-1.50	Class 2	16.5-19.0	-	< 1000	< 2000	< 4000
	HF-150S	1.35-1.55	Class 2	16.5-19.0	-	< 500	< 1000	< 2000
	HF-250S	1.35-1.55	Class 2	16.5-19.0	-	< 200	< 400	< 700
Double Surface Treatment	CRS-2 RS-2 HF-100S	1.60-1.70	Class 3[2]	15.0-17.5	-	< 1000	< 2000	< 4000
		1.05-1.15	Class 4[1]	6.5- 8.0				

Notes:

1. Class 4 - Aggregate is referred to as sand cover in MTC Form 302 and as sand seal in MTC Form 303, dated March, 1982.

2. Class 3 - Aggregate is referred to as coarse aggregate in MTC Form 303, dated March, 1982.

TABLE 2: RECOMMENDED SURFACE TREATMENT TYPES AND APPLICATION RATES BASED ON TRAFFIC VOLUMES AND EXISTING ROAD SURFACE

9.4 Zahn Viscosimeter Test For Emulsified Asphalt

Equipment

1. Zahn viscosimeter cup No. 3. (Fig. 1)
2. Stop watch.
3. Thermometer range $40^{0}C$ - $90^{0}C$.
4. Gallon sample cans.
5. Mineral spirits (varsol).
6. Rags.
7. Table 3 used to determine viscosity in Saybolt Furol seconds at $50^{0}C$ for emulsified asphalt.
8. Table 4 showing acceptable viscosity range in Saybolt Furol seconds at $50^{0}C$.

Procedure

1. Obtain emulsion sample in one-gallon can.
2. Immediately take emulsion temperature and record.
3. Immerse Zahn cup into emulsion until the top of the cup is approximately 15 mm below emulsion surface (Fig. 2).
4. Allow the cup to warm up (1 - 2 minutes).
5. Lift the cup until the rim of cup is just below the surface.
6. Lift the cup out of the emulsion and at the same time start the stop watch. (Fig. 3).
7. When the stream breaks, stop the stop watch. (Fig. 4).
8. Record the time in the nearest 1/10 s.
9. Repeat the procedure 3 times taking the average time to the nearest second.
10. Record the average viscosity in Saybolt Furol seconds at $50^{0}C$ as determined using Table 3.

Notes 1. The test must be performed within the temperature range $60^{0}C$ to $80^{0}C$. If the sample is above $80^{0}C$, it should be allowed to cool to less than $80^{0}C$ before testing. If the emulsion as delivered is below $60^{0}C$, a decision has to be made either to reject the material because of low temperature or to heat the material on site above the minimum of $60^{0}C$ before sampling and testing. Do not attempt to heat the sample.

Notes continued

2. One Zahn test (average of three readings) is required for each tanker load of emulsion.

3. The sample taken for Zahn testing can be used as the field sample submitted for laboratory results.

4. Some judgement is necessary when stopping the time. The stream becomes narrow and then breaks. Stop the time when the stream first breaks.

Seconds for Flow Thru Zahn Cup No. 3 @ 60 to 80°C	Saybolt Furol Seconds @ 50°C	Seconds for Flow Thru Zahn Cup No. 3 @ 60 to 80°C	Saybolt Furol Seconds @ 50°C
5	12	31	90
6	15	32	93
7	18	33	96
8	21	34	99
9	24	35	102
10	27	36	105
11	30	37	108
12	33	38	112
13	36	39	115
14	39	40	118
15	42	41	121
16	45	42	124
17	48	43	127
18	51	44	130
19	54	45	133
20	57	46	136
21	60	47	139
22	63	48	142
23	66	49	145
24	69	50	148
25	72	51	151
26	75	52	154
27	78	53	157
28	81	54	160
29	84	55	163
30	87		

TABLE 3, FOR DETERMINING VISCOSITY IN SAYBOLT FUROL SECONDS AT 50°C FOR EMULSIFIED ASPHALT

Grade	Saybolt Furol, Seconds at 50°C	
	Min.	Max.
RS-2	72	303
MS-2	72	303
CRS-1	47	153
CRS-2	97	403
CMS-2	47	403
CMS-2H	47	403
HF-100S	32	153
HF-150S	32	153
HF-250S	32	153
HF-300M	47	-
HF-500M	47	-
HF-1000M	47	-

TABLE 4: SHOWING ACCEPTABLE VISCOSITY RANGE AT 50°C FOR EMULSIFIED ASPHALT

EQUIPMENT FOR PERFORMING ZAHN CUP VISCOSIMETER TEST MAY BE OBTAINED FROM:

CanLab Laboratory Equipment,
80 Jutland Road,
TORONTO, Ontario.
M8Z 2H4
(416) 252-5151

- OR -

Fisher Scientific Co. Ltd.,
184 Railside Road,
DON MILLS, Ontario.
M3A 1A3
(416) 445-2121

	APPROXIMATE COST
Order - Zahn Viscosimeter Cup No. 3, Orifice Diameter 3.75 mm	$106.00 each
Order - Dial Thermometer, 0-150°C	$ 35.00 each
Order - Stop Watch, 0-60 s	$ 77.00 each

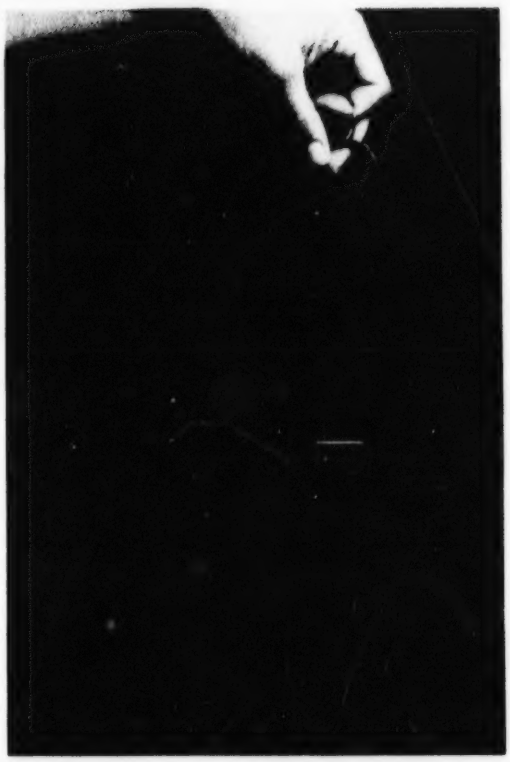

Figure 1: Zahn Viscosimeter

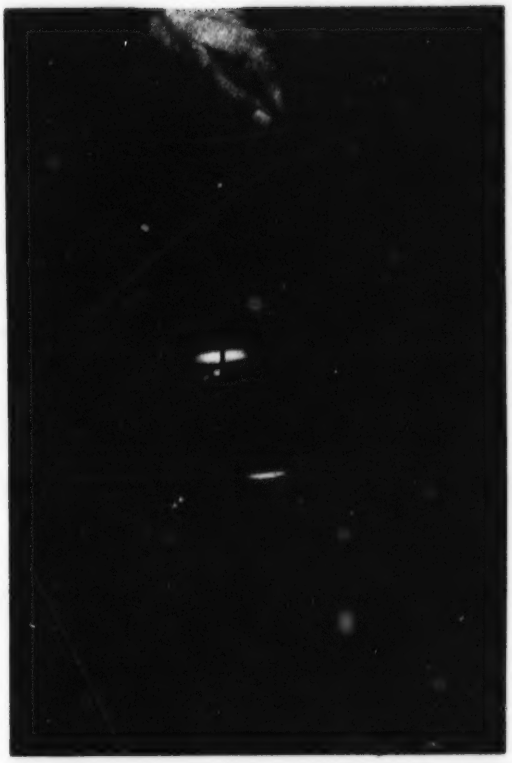

Figure 2: Zahn Cup Immersed

Figure 3: Timing Begins

Figure 4: Timing Stops

NOTES: